# 9

# UNPACKING AND INSTALLATION

# 9. UNPACKING AND INSTALLATION

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# 9. UNPACKING AND INSTALLATION

In the US, UK, or countries which have a resident Oxford Lasers' distributor, the laser will be installed by Oxford Lasers or its distributor's personnel. In other countries, it is STRONGLY RECOMMENDED that the purchaser makes arrangements for an Oxford Lasers' Service Engineer to travel there to carry out initial installation. Should the purchaser not wish to do this, the installation instructions included in this chapter should be followed. IT SHOULD BE NOTED HOWEVER, THAT INCORRECT OR FAULTY INSTALLATION OF THE LASER MAY INVALIDATE THE WARRANTY. THEREFORE THE FOLLOWING PROCEDURE SHOULD ONLY BE CARRIED OUT BY TRAINED SERVICE PERSONNEL.

## 9.1 PREPARATION OF A ROOM FOR THE LASER

The room chosen to accommodate the laser should be large enough to ensure that easy access is afforded to the laser head and to the front, rear, and both left hand and right hand sides of the Power Supply Unit (PSU).

The approximate external dimensions of the lasers are given in table 9.1.

Table 9.1 System dimensions

| | | LENGTH (mm) | WIDTH (mm) | HEIGHT (mm) |
|---|---|---|---|---|
| LASER HEAD CU10-A | | | | |
| | STANDARD | 1258 | 310 | 225 |
| | EXTENDED | 1865 | 310 | 225 |
| LASER HEAD CU15-A | | | | |
| | STANDARD | 1558 | 310 | 225 |
| | EXTENDED | 2165 | 310 | 225 |
| POWER SUPPLY UNIT | | | | |
| | | 682 | 487 | 731 |

The laser head and the PSU are connected via a flexible umbilical cable which carries services between the two. This cable is 2m long and has a minimum bend radius of 0.2m. The umbilical is connected at the top on the rear panel of the power supply and at the High Voltage (HV) end of the laser head. The laser head should be supported on a sturdy and level bench at least as long and wide as the laser head. The height of the bench is a matter for the user to decide, but safety considerations will generally dictate that bench heights which permit the laser beam to propagate near eye level should be avoided. The axis of the 20mm or 25mm diameter laser beam will appear some 115mm above the height of the bench.

The room should be a designated laser area and warning LASER AREA signs should be fitted to the entrances of the room. Access to the room should be restricted to authorised personnel only. It is the responsibility of the user to ensure that authorization has been obtained to operate a high power laser and that all the required preparations have been made to the room BEFORE the arrival of the Service Engineer who will install the laser.

## 9.2 SERVICES REQUIRED FOR THE LASER

In this section the services required for the operation of the lasers are specified. In each subsection items which the user should obtain prior to the arrival of the Service Engineer are noted.

### 9.2.1 Electricity Supply

The laser requires a 208V/220V/240V, 50/60Hz single phase electricity supply. The circuit must be capable of supplying 3kW. If such a supply is not available from the electricity generating authority, the purchaser should inform Oxford Lasers of this fact before the laser is shipped.

### 9.2.2 Air Cooling

This series of lasers utilize air-cooling, the air is drawn in and blown out by fans over certain parts of the laser system.

The CU10-A laser head has three fans, these are located on the left hand side of the laser head. Two of fans draw in air and cool each of the end flanges and are located at each end. The fan located in the centre draws hot air out. The fans operate as soon as the HV is switched on and continue to run for 30 minutes after the HV or the power supply is switched off. This operation is controlled by a power supply board and a back up rechargeable battery. There is also an emergency fan start facility on this board if the electricity supply fails during operation to avoid any irreparable damage being caused to the laser head.

The CU15-A has four fans rather than three, the fans are located on the same side as the CU10-A and operate in exactly the same manner. Two fans draw in air at each end of the laser head over the end flanges and the other two draw the air out at the centre.

The PSU on all these models are exactly the same and contains three fans which all draw air in. Two of the fans are mounted in the right hand side panel, which is the High Voltage side. One of the fans draws air over the Thyratron Tank and the other draws air over the High Voltage components. The third fan draws air over the vacuum pump which is on left hand side of PSU (low voltage side). There also three air vents and these are located in the rear panel of the PSU.

It is very important that both the PSU and the Laser Head should be positioned such that all the inlet and outlet fans are free from obstruction. A space of at least 40cm is required for free air circulation.

### 9.2.3 Neon Gas Supply

Copper vapour laser systems require a supply of CP grade neon (British Oxygen Corporation specification: see Chapter 11) if operation at maximum power output is desired. This gas supply should be capable of independent regulation between 1 and 3 bar absolute.

The Compact Laser has been specifically designed so that an external or internal gas supply can be used. The supply line from the external gas cylinder is connected to the inlet port on the rear of the PSU, which is a 1/4 inch Swagelok connection (a 6mm connection will be provided if necessary). The user should supply suitable 1/4 inch outside diameter piping to connect to this port from the cylinder(s) of gas, or other supply point. For the internal supply option, there is a space provided on left hand side of the PSU (low voltage side) for a small gas cylinder. A 1/4 inch pipe and Swagelok connection has been supplied, one side of which is already connected to the laser vacuum system via a T-tap. The other end of this pipe should be connected to the cylinder. The cylinder should be fastened down securely using the metal straps that have been provided. The T-tap is fitted so as to allow selection between

external and internal gas . The midway way position of this T-tap shuts off the gas supply to the laser head. Note that the internal cylinder and gauge are not provided with the system. Further information on the size of the internal cylinder and regulator may be obtained from Oxford Lasers.

### 9.2.4 Vacuum Pump

Each laser is fitted with rotary vacuum pump as a standard item for evacuating the laser discharge tube. The pump is capable of attaining a ultimate vacuum of $10^{-2}$ mbar and pumping speed of 50 litres/minute. The pump is fitted with anti-suckback protection and an oil mist filter.

It is very important to check that the pump is filled with oil before connecting system to the power line. The level of the oil can be checked by viewing through the sighting glass on rear of the pump. If the level is low the pump can be topped up with the vacuum oil provided with the laser, maximum oil capacity of the pump is 0.3 litres. The pump should never be allowed to run dry. Further information of maintenance of the pump can be found in the rear of this manual (Chapter 11 Appendices).

### 9.2.5 Transformer Oil for the Thyratron Tank and HV Circuitry

Approximately 4.7 litres of Shell Diala BG transformer oil, or equivalent, is required for the tank which contains the Thyratron and other HV circuitry. A 5 litre can of this oil is supplied. It is important not to over-fill the Thyratron tank, and to ensure that the oil seal is replaced and positioned correctly.

### 9.2.6 Location of the service ports

The location of the various service ports are shown in figure 9.1, and described in table 9.2. All the service ports are located on the rear panel of the PSU.

Table 9.2 Service panel details

| No. | SERVICE PORT | | DESCRIPTION |
|---|---|---|---|
| 1 | Umbilical Cable Between PSU and Laser Head carrying the following: | | |
| | a) | HV line | 1/2 inch Coaxial cable |
| | b) | Gas in line | 1/4 inch O/D Nylon tube |
| | c) | Gas pump out line | 3/8 inch O/D Nylon tube |
| | d) | Laser head interlock lines | 7/02 white wire |
| | e) | Operational control lines for solenoid valves | " |
| | f) | Operational control lines for fans | " |
| | g) | HV on lamp indicator lines | " |
| | h) | Auxiliary head dirt monitor lines | " |
| | *j) | External control lines for medical system | 12-way connector |
| 2 | Gas In Port | | 1/4 inch Swagelok Fitting |
| 3 | Gas Inlet Selector | | Swagelok Three-Way Tap |
| 4 | Single Phase Power Supply Cable | | Single Phase,Neutral and Earth. 13 Amp Cable |
| 5 | Power Supply Input Fuse | | Anti-Surge 15 Amp Fuse |
| 6 | HV Circuit Breaker | | 20 Amp MCB (Resettable) |
| 7 | External Interlock Extension Facility | | Three Pin Female Plug (see circuit diagrams) |
| 8 | Three Air Outlets | | 4 inch Diameter fan ducts |
| 9 | External meter connection socket | | Nine pin female interface socket |

* Applies only to lasers equipped with medical systems

4) Remove the capping plugs from the gas manifold on the central earth plate and connect the umbilical gas in and gas out pipes to these points (figure 9.5 No.7 and 8).

5) Connect the umbilical multi-way connector to the connector mounted on the base inside the case (figure 9.6 No.12)).

6) Connect the vacuum gauge provided in the installation kit in line with the existing gas out manifold gauge on the laser head; a blanked port has been provided for this purpose (see figure 9.5 No.3).

### 9.3.3 Filling the Vacuum Pump and Thyratron Oil Tank

The PSU has a central partition (centre panel) which separates the main High Voltage operating components from the control system. The right hand side of the PSU contains the High Voltage circuits and the left hand side the control electronics.

The vacuum pump is found in the left hand section of the PSU and its oil level should now be checked through the sight glass on the rear of the pump. If the oil level is below the lower case marking, or if the pump has been shipped dry (e.g. for air freighting), then the pump should be filled with oil. A can of suitable vacuum pump oil is provided in the laser installation kit.

Note: The pump should not be over filled.

Check that an oil mist filter is fitted to the pump exhaust. A spare filter is included in the complimentary spares kit.

The thyratron tank should also be filled at this point. It is found at the back of the right hand compartment. The tank will hold approximately 4.7 litres of a high quality transformer oil such as Shell "Diala BG" which is provided in the installation kit. The tank should be filled through the plugged aperture in the tank lid.

Note: Once more, take care not to over fill, and wipe clean any oil spilled.

### 9.3.4 Connecting the External Power and Gas Supplies to the Laser

#### 9.3.4.1 Connecting the External Power Supply

The laser requires a single phase, 50/60Hz supply, and will have been set up at the factory for either 208V or 240V operation. The external power cable should be connected to the supply, which must be capable of providing up to 16A as follows:

| | |
|---|---|
| Brown | Live |
| Blue | Neutral |
| Green/yellow | Earth |

The earth connection should remain after laser operation to provide a safe discharge path for the internal capacitors.

Note: Supply voltages are present within the laser as soon as it is connected to the power supply socket.

Connect the laser to a suitable power supply. Operate the key switch on the PSU front panel; the laser system should now be active.

This is an appropriate point at which to start evacuating the vacuum system. Locate and depress the FAST GAS OUT override switch (Fig. 9.7 No. 3) at the rear of the left hand compartment of the PSU. Then close the GAS IN manual regulating valve (Fig. 9.7 No. 2) to the right of the override switch by turning it fully clockwise. The pressure indicated by the vacuum gauge fitted to the laser head should now start to fall.

## 9.3 ASSEMBLY OF THE LASER

### 9.3.1 Initial Checks

When delivered to countries outside the U.K., the laser will have been dismantled according to the method of shipment. The laser is air-freighted as the following units.

a) The laser head.

b) The power supply unit.

c) The installation kit, including the complimentary spares kit.

d) Optional accessories, such as dye laser parts or unstable cavity optics.

The purchaser should be satisfied that none of these components has suffered any damage in transit before proceeding with the installation.

Installation of the laser consists of:

1) Connecting the laser head, via the umbilical cables, to the Power Supply Unit (PSU).

2) Filling the vacuum pump and the thyratron tank with their respective oils.

3) Setting up the power supply electronics.

4) Connecting the external power and gas supplies to the laser.

5) Setting up the vacuum system and checking its integrity.

6) Conditioning the laser head.

7) Initial running of the laser.

The person assembling the laser should be familiar with the use of Swagelok to avoid problems with vacuum integrity of the gas handling system. Some notes explaining the use of Swagelok are contained in Chapter 11.

### 9.3.2 Connecting the Laser Head to the Power Supply Unit (PSU)

Assembly of the laser head requires the removal of all packing material, fitting of the umbilical cable, and checking of the optics. Even when already connected to the PSU, the laser head contains packing material for shipping. When shipped the laser head is filled to atmospheric pressure with helium in order to avoid excessive contamination from moisture.

1) Remove the crosshead screws retaining the cover of the laser head using the crosshead (Philips) screwdriver, supplied in the complimentary spares kit. Remove the lid from the work area. Remove beam path cover and the rear optic mount which then gives access to the high voltage (HV) end of the laser head through which the umbilical cables enter the laser head. Remove all packing materials.

2) Thread the umbilical cables through the hole in the end cover plate and attach the umbilical outer to the laser head using the four cap head screws provided.

3) Connect the earthed braid of the coaxial HV cable to the earth plate, which is the right hand side of Peaking Capacitor and ensure that it is tightened down securely with the M4 caphead screw for a good earth return. Connect the core of the coaxial cable to the high voltage end flange to the left of the Peaking Capacitor and secure similarly. Ensure all screws and nuts are tight on this end of the laser head (Figure 9.6 No. 9).

#### 9.3.4.2 Connecting a Gas Supply to the Laser

The gas supply should now be connected to the laser. It is good practice first to bleed all gas lines and to maintain a small flow of gas throughout the operation.

Either a) Connect the laser to an external gas supply, regulated to 2bar. Use the 1/4 inch nylon pipe supplied in the installation kit with a 1/4 inch Swagelok nut from the spares kit, and connect to the "external gas supply" port at the rear of the PSU.

or b) Fit an appropriate gas bottle and regulator inside the laser, using the pipe and fitting already present (Fig. 9.4 No. 10). The blanking nut should be removed from the pipe first.

In both cases, the regulated supply pressure should be set to 2bar gauge.

The "gas supply selector" valve at the rear of the PSU should now be set appropriately.

### 9.3.5 Setting Up The Power Supply Electronics

The laser control system is centred on the relay motherboard which is mounted on the left hand side of the central panel towards the front of the PSU (see fig 9.8).

1) Check that all relays and modules are correctly and securely connected.

2) Check that none of the functions and modules have been overridden. To ensure this is the case the toggle switches should all be switched towards the left hand position (figure 9.9 No.3).

3) Check that no other components located on this side of the power supply cabinet have suffered any damage during transit.

Before running the laser, it is advisable to check its major subsystems for correct operation. This involves:

a) Checking the operation of the Clock Pulser and the high voltage trigger units.

b) Checking the grid bias voltages and heater voltage on the thyratron (refer to safety warning, section 9.3.4.4 below).

c) Checking that the thyratron control module (for the thyratron heater timer) is operating correctly.

#### 9.3.5.1 Checking The Clock Pulser

The correct operation of the clock pulser must be checked using an oscilloscope.

The clock pulser is located on the top front panel of the PSU. With the power on, and the TRIGGER select set to INTERNAL or AUTO-SYNC, the liquid crystal display should show the pulse repetition frequency in kHz. Check that the unit is pulsing by connecting an oscilloscope probe into the BNC socket at the rear of the unit. The unit should produce a square wave approximately 15V in amplitude.

The signal from the clock pulser is processed by the high voltage trigger unit before being applied to the thyratron. Operation of the high voltage trigger unit is checked in the following section.

### 9.3.5.2 Checking the Thyratron Heater and Grid Supplies

CAUTION:

LETHAL VOLTAGES MAY BE PRESENT WITHIN THE PSU EVEN WHEN INTERLOCKS ARE PROPERLY OVERRIDDEN

Important **Before attempting to carry out the thyratron grid or heater voltage checks, it is important first to disable the high voltage circuit breaker on the rear of the PSU (Fig. 9.1 No. 6). In order to do this, the black circuit breaker button should be pulled out until it clicks; the button will be approximately 20mm proud of the panel (on early models with a red sleeve, the sleeve should be pulled out to release the button). Disabling the circuit breaker will prevent high voltages being present during checks.**

The high voltage trigger unit takes the low voltage signals from the clock pulser unit and generates short, high voltage trigger pulses which are superimposed upon bias voltages and fed to the grids of the thyratron valve. The unit is connected to the thyratron tank via a separate coaxial, BNC-terminated lead for the two grids; test points are provided on the top of the thyratron tank to check the voltages supplied to the grids, as well as a measuring point for the thyratron heater voltage.

The high voltage trigger unit and the heater transformer which provides its power are mounted together in the right hand compartment of the PSU. The transformer also provides ac power for the thyratron heater. In order to check the thyratron heater and grid supplies, the top and right hand side panels and safety screens must be removed. This breaks the PSU interlock which should therefore be overridden by switching over the "PSU and Laser head" interlock override switch on the interlock control module. In this state the PSU will work through its sequence without activating the high voltage circuits which power the laser.

With the PSU panels interlocks overridden, and the main laser key switch turned on, the "Ready" indicator on the front panel should flash. The laser START button should now be depressed to initiate the power supply warm-up sequence.

Switch the clock pulser to EXTERNAL and verify that the correct signal is present at the following points:

| | |
|---|---|
| Thyratron heater monitor point (on thyratron tank) | 6.5Vac ± 5% |
| Thyratron positive grid monitor point (marked "+" on thyratron tank) | +160 to +190Vdc, falling over 5-10 minutes to settle at 18-35Vdc. |
| Thyratron negative grid monitor point (marked "-" on thyratron tank) | -160 to -190Vdc |

Note: All the above measurements will reflect changes in the external power supply voltage; if significant variations in the line voltage are common, steps should be taken to stabilize the supply.

The thyratron heater voltage can be adjusted by selecting a different tapping on the input to the multiple-tapping heater transformer. The laser should be stopped before carrying out this operation.

Switch the CLP to INTERNAL and, using a suitable high voltage oscilloscope probe, verify that trigger pulses are superimposed upon the negative grid bias voltage. The trigger pulses, with a risetime around 50ns, should measure approximately 1500V when the thyratron is still cool, but will fall to around 400V as the thyratron warms up.

The steady state voltage at the positive grid can be used to monitor the condition of the thyratron. When the device is new, a voltage between 18V and 24V will be observed. As the thyratron ages, this will rise towards 35V, when the thyratron will probably need replacing. It should be noted that the voltage will be anomalously high for the first few hours following a prolonged period without use.

### 9.3.5.3 Checking the Thyratron Control Module

Check that the HEATER DELAY operates in no less than seven minutes. This time is controlled by the trimpot on the PCB which is mounted on the motherboard. Anticlockwise rotation reduces the time delay whereas clockwise rotation increases it. This is usually factory set to 10 minutes.

After all these checks have been carried out, the panels can be replaced and the interlock override switches can be returned to the normal position.

Note: If the interlocks are overridden, the high voltage should be disabled.

### 9.3.6 Setting up the Vacuum System and Checking Its Integrity

If the FAST GAS OUT override switch and GAS IN manual regulating valve were correctly set as per section 9.3.4.1, the laser will by now have evacuated, and the vacuum gauge should read less than 10mbar. The laser head window retaining ring screws should now be tightened until resistance is just felt and the system left to pump down for a further 5 minutes. The integrity of the vacuum system should now be checked. First set the Condition Timer switch to NORMAL.

1) Switch off the FAST GAS OUT override switch.

2) Open the GAS IN manual regulating valve and fill the laser tube, by depressing the FAST GAS IN override switch, to approximately 500mbar.

3) Return the FAST GAS IN override switch to its upper position, and close the GAS IN manual regulating valve.

4) Depress the FAST GAS OUT override switch and leave the laser to pump for an hour. The pressure of the laser system should then be down to 5mbar or less. If this is not the case, leave the laser to pump down for a further 30 minutes. If the pressure then remains above 5mbar, the seals of the vacuum system should be investigated.

5) Once the laser pressure is below 5mbar, the laser should be isolated by closing the GAS OUT manual regulating valve and returning the FAST GAS OUT override switch to its upper position. The laser pressure should now be noted, and the system left for two hours. If the pressure rises by more than 2mbar, the integrity of all gas seals must be checked and the leak fixed.

6) The laser should now be left to evacuate with the FAST GAS OUT override switch depressed and the GAS OUT manual regulating valve open for approximately 4 hours.

The buffer gas flow rate should now be checked to ensure that the internal gas regulator has not been disturbed in transit. This should always be done whilst the laser tube is cold. The high voltage circuits should first be disabled by operating the "PSU Panels" interlock override switch on the interlock module. (see Figure 9.9).

1) Check that neon is supplied to the laser at a pressure of 2bar.

2) Open both manual regulating valves and ensure that both FAST GAS override switches are in the upper position. The gas and vacuum lines will now be connected to the laser head via factory-fitted constrictors. The equilibrium pressure which is eventually attained thus depends upon the setting of the internal gas pressure regulator.

3) Allow the pressure in the laser tube to stabilize (approximately 10 minutes) and check that the pressure is in the range 35-60mbar, adjusting the internal gas pressure regulator if necessary.

4) Now close the GAS OUT manual regulating valve and measure the rate of rise of pressure over a 10 minute period. The rise should be in the region of 1-2mbar/minute.

## 9.4 CONDITIONING THE LASER HEAD

Reliable, high power operation of metal vapour lasers will not be achieved unless the laser tube is free of impurities. Significant damage, and probably failure, to the thyratron will occur if the laser head is not properly conditioned. Proper conditioning requires as a first step a leak-tight gas system and high purity supplies of neon.

If the laser has had to be dismantled for shipment significant contamination of the laser tube will have occurred. Conditioning of the laser tube and the achievement of maximum laser output power may take a few days from first switch on of the laser.

The major impurities are water and oxygen. These impurities can only be removed by heating the laser tube with the discharge. Unfortunately, because the impedance of the resonant charging circuit and its "load" (the laser tube) are badly matched when there are impurities in the system, it is possible for an inexperienced operator to seriously damage, and possibly destroy, the thyratron switch or other components whilst carrying out the conditioning procedure.

In this section a suggested procedure is given for conditioning the laser tube.

### 9.4.1 Control of Buffer Gas Flow

**CAUTION:**

**THESE LASERS SHOULD NEVER BE OPERATED FOR EXTENDED PERIODS AT PRESSURES BELOW THOSE RECOMMENDED. OPERATION IN THIS MODE MAY RESULT IN IRREPARABLE DAMAGE TO THE LASER OPTICS, THE ELECTRODES, THE END FLANGES AND POSSIBLY THE THYRATRON OR OTHER COMPONENTS.**

Table 9.3 Compact laser buffer gas

All information for Buffer Gas = NEON (Ne)

NORMAL RUNNING PRESSURE WHEN LASER IS CLEAN

| | |
|---|---|
| Pressure upon initial switch on | 10mbar + 10% |
| Pressure when lasing at full power | 50mbar + 10% (see given parameters) |
| Flow rate per minute | 1 - 2mbar |

Note: Pressure needs to be reduced if discharge does not strike correctly.

CONDITIONING LASER PRESSURE WHEN LASER IS CONTAMINATED

| | |
|---|---|
| Pressure upon initial switch on | 5mbar + 10% |
| Pressure when warm | 10mbar + 10% |
| Pressure when lasing | 20mbar + 10% |
| Flow rate per minute | 4 - 5 mbar |

Note: Maximum output power cannot be achieved when reconditioning.

### 9.4.2 Conditioning The Laser Head

Note: The following procedure is only required after excessive contamination of the laser tube. Conditioning following copper recharging should only take a few hours.

The conditioning process consists of heating the laser tube with the discharge for short periods in order to drive off moisture which may be present. A higher gas flow rate and a lower gas pressure than normal is used initially. Between the periods of heating the laser tube is evacuated to remove those impurities which have been driven off.

The laser is fitted with a Condition Timer which automatically provides for a period of fast gas flow each time the laser is turned on. The reconditioning of a tube should be achievable by repetetive operation of the laser. The laser is turned on in the usual way (Section 4.3.1) until the Dirt Monitor switches the laser off. When this happens the laser is flushed through with clean gas and then pumped out for a period before the process is repeated. The details of this process are described below.

1) Set the frequency control unit to 10kHz and switch to INTERNAL.

2) Switch the GAS OUT and GAS IN override switches to the up position so that the laser is under the control of the Condition Timer.

3) Swith the Condition Timer to CONDITION.

4) Ensure that none of the interlocks are overridden, and all covers are in place and that it is safe to switch on.

5) The READY LED should be flashing. By depressing the start switch the first sequence LED will light. This indicates the operation procedure has started and the laser is pumping down while the Thyratron is warming up. This will continue for 7 minutes after which the HIGH VOLTAGE will be activated and the second sequence LED will light. The laser voltage and input power will automatically rise to the preset values. If an external read-out meters are supplied, the voltage will be seen to rise and the auxiliary current will be seen to increase rapidly to a high value, fall to approximately zero, then rise again. If this does not occur for voltages above 4.0kV, switch off <u>immediately</u> and start again at step (7). If it does happen proceed to step (8). The laser should now be discharging.

6) Using a suitable neutral density filter, look down the discharge tube. The discharge should be seen to be striking down the tube; if it is not, switch off immediately by depressing the STOP switch, and reduce the pressure by restarting the operating procedure again. This will pump out the laser head during the 7 minute Thyratron heater delay.

**WARNING**

**COLLATERAL RADIATION IN THE ULTRAVIOLET AND INFRARED SPECTRA REGIONS IS ALSO EMITTED FROM THE DISCHARGE. THEREFORE, NEVER LOOK DOWN THE DISCHARGE TUBE WITHOUT USING A SUITABLE NEUTRAL DENSITY FILTER WHICH WILL BLOCK THE UV AND INFRARED EMITTED**

**NEVER LOOK DOWN THE TUBE WHEN THE DISCHARGE IS ON AND THE TUBE IS HOT**

7) When the laser has been restarted, the discharge should be the characteristic bright orange-red colour of neon. A blue or white discharge indicates contamination.

8) Run the laser until the dirt monitor causes the laser to trip out or the discharge becomes "snaky", i.e. constricted and twisting, then switch off.

9) When the laser is off, flush through with buffer gas by filling laser to approximately 500mbar by switching the Condition Timer to NORMAL and using the GAS IN override switch.

10) Repeat steps (5) - (9). As the laser cleans up it should run for longer and longer periods before the dirt monitor switches the laser off. Following each time that the Dirt Monitor turns off evacuate the laser for a time at least equal to the running period just completed before you attempt to restart the laser. The Condition Timer will provide fast gas flow for a period of about twenty minutes after the laser has been turned on. When a tube is being reconditioned it is sometimes necessary to provide fast gas flow for longer than this. To provide continuous fast flow the Condition Timer should be set to "NORMAL" and the GAS IN and GAS OUT switches should be switched down. Both manual gas valves should be fully open.

11) At the end of the day, switch off the laser, and allow tube to cool for 30 minutes. Fully pump the laser out by switching the Condition Timer to "NORMAL" and then the GAS IN switch to the up position, closing the GAS IN manual valve. Leave the laser to be pumped out overnight.

12) Next day, start up laser again as described above, and run for at least two hours.

13) After two hours, if the discharge looks clean and has a green hue combined with the orange-red of the neon, or is actually lasing, switch off and pump down system for 30 minutes. Start up the laser again. The laser voltage and input power will automatically rise to the preset values. If an external read-out meters are supplied, the voltage will be seen to rise and the auxiliary current will be seen to increase rapidly to a high value, fall to approximately zero, then rise again. If this does not occur for voltages below 4.5kV, switch off immediately and start again at step 4) (see Chapter 3). The laser should now be running. Run the laser for a further day. When the laser is lasing, switch the GAS IN and GAS OUT switches to the up position. If the laser continues to run like this then switch the Condition Timer back to "CONDITION" before running up the next day. If the Dirt Monitor switches the laser off then continue to run the laser on fast gas flow.

14) Continue to run the laser until it will run up from cold to lasing with the Condition Timer set to "CONDITION", both the gas switches up and both the gas valves fully open.

15) The following day remove the windows and clean them. Make sure that there is gas flow out of the tube when either window is removed. A wad of tissue placed in the open end will help to reduce recontamination.

16) Replace the windows paying careful attention to the cleanliness of the O-ring seals and their locating grooves in the end flanges. Start the laser and run for 2 - 3 hours. Reset both the GAS IN and GAS OUT switches to the up (off) position and fully open both GAS IN and GAS OUT manual valves. Set the Condition Timer to "CONDITION". The laser is now ready for normal service.

### 9.4.3 An Alternative Method of Monitoring Laser Performance During the Conditioning Process

There is a safer way of monitoring the performance of the laser during the conditioning process. However, two pieces of test apparatus are required: an oscilloscope with a 50ns/div writing speed and a 100MHz bandwidth, and a fast response high voltage probe rated to 30kV.

The major problem during the conditioning process is the effect the poor discharge has on the Thyratron switch. Monitoring the rise and fall of voltage on the Thyratron anode and responding when it is seen that the Thyratron is being operated in an adverse mode will help safeguard the Thyratron. Figure 9.14 shows the appearance of the voltage trace from the Thyratron anode, (a) when the laser is clean and (b) when there are impurities present. It should be noted that it is easier to produce a trace such as that shown if the oscilloscope is electrically screened and if the bandwidth is limited to 20MHz.

There are two parameters which need to be monitored:

a) The average voltage overswing at the tail of the pulse

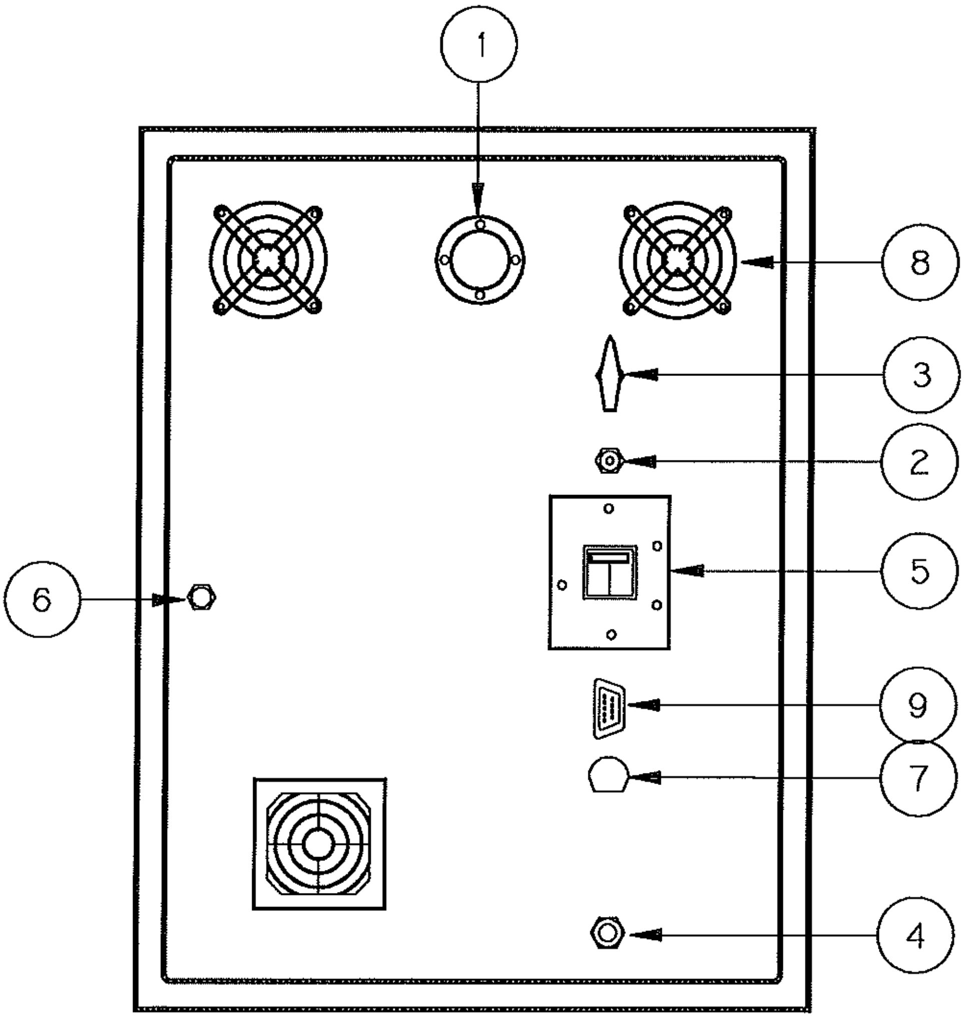
b) The inverse voltage.

See figure 9.14 a & b.

Neither the voltage overswing nor the dirt spike should ever be allowed to exceed 10kV. There is a convenient connection point to the Thyratron anode at the top of the rear feedthrough post to the Thyratron tank behind the charging capacitor assembly (Fig. 9.10 No.2).

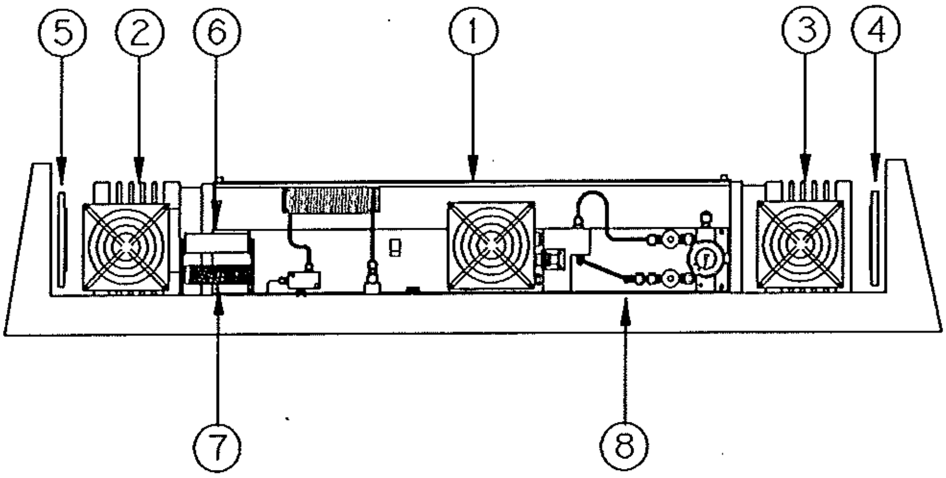
The behaviour of the dirt spike is such that it will be seen to increase in magnitude as the laser tube becomes warm. However, if lasing temperature is reached, the metal vapour will start to dominate the discharge and the dirt spike will disappear. It is in the time between first switch on and the achieving of lasing temperature that the spike needs to be monitored. It should be borne in mind that the spike generally appears very quickly. Increasing the laser voltage will cause a temporary decrease in the magnitude of the spike - as will flushing fresh gas through the system using the manual mode. However, it will usually be the case that the laser has to be shut down and the impurities pumped away. This is the reason that section 9.4.3 advises "switch off and pump down" at regular intervals.

The behaviour of the voltage overswing is such that when the laser is cold it is relatively small. It reaches its maximum value when lasing temperature is reached. Increasing the laser voltage causes an increase in the overswing. Reductions in gas pressure also result in an increased voltage overswing.


1
8
3
2
5
6
9
7
4

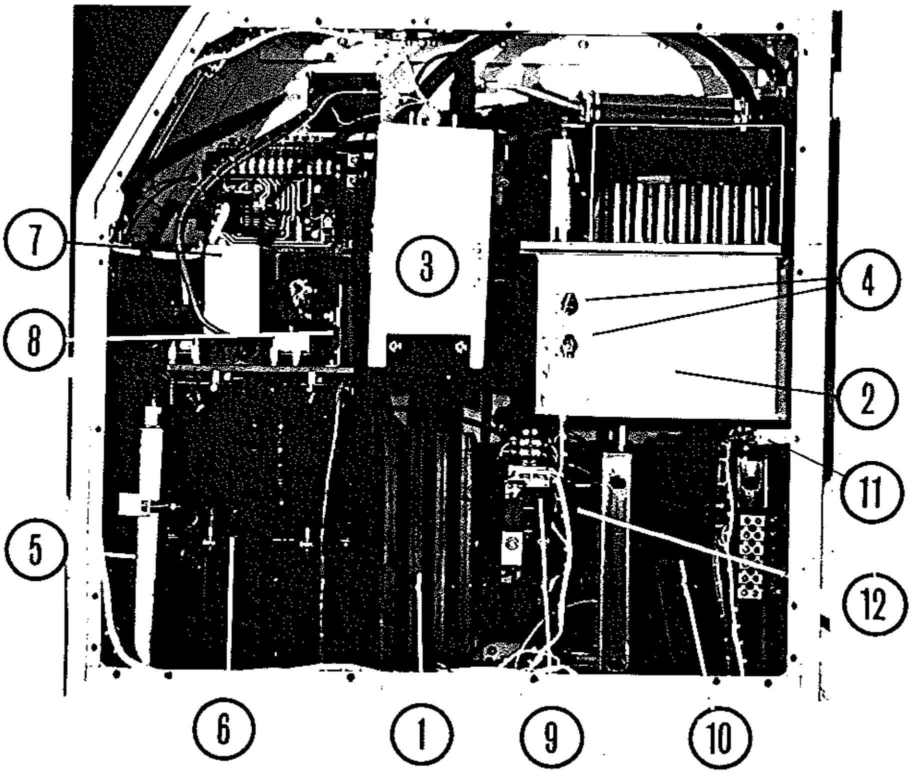
1. Umbilical Cable
2. Gas In Port
3. Gas Inlet Selector
4. Single Phase Power Supply Cable
5. Power Supply Fuse
6. HV Circuit Breaker
7. External Interlock Extension Facility
8. Air Outlets
9. External Meter Connection Socket

Figure 9.1 Services panel



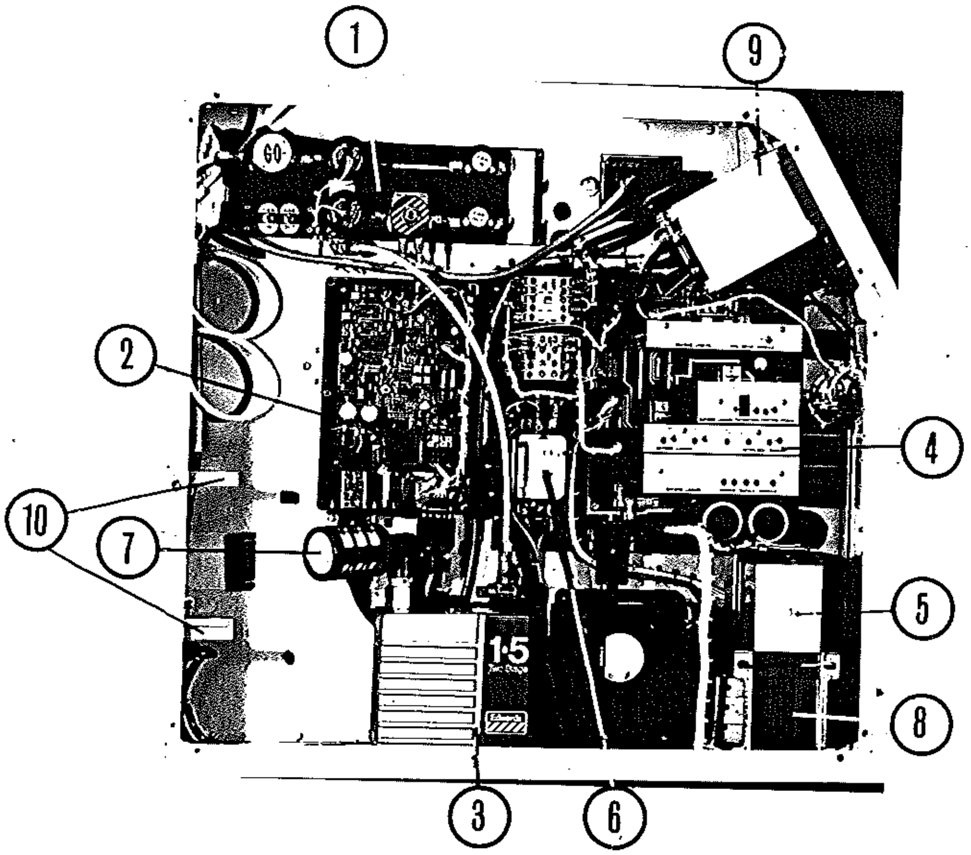

1. Laser QVF assembly
2. HV end flange
3. Earth end flange
4. Output coupler (spec. B optic)
5. Reflective 100% mirror
6. Peaking capacitor
7. Charging inductor
8. Laser head gas handling system

Figure 9.2 Detail of laser head



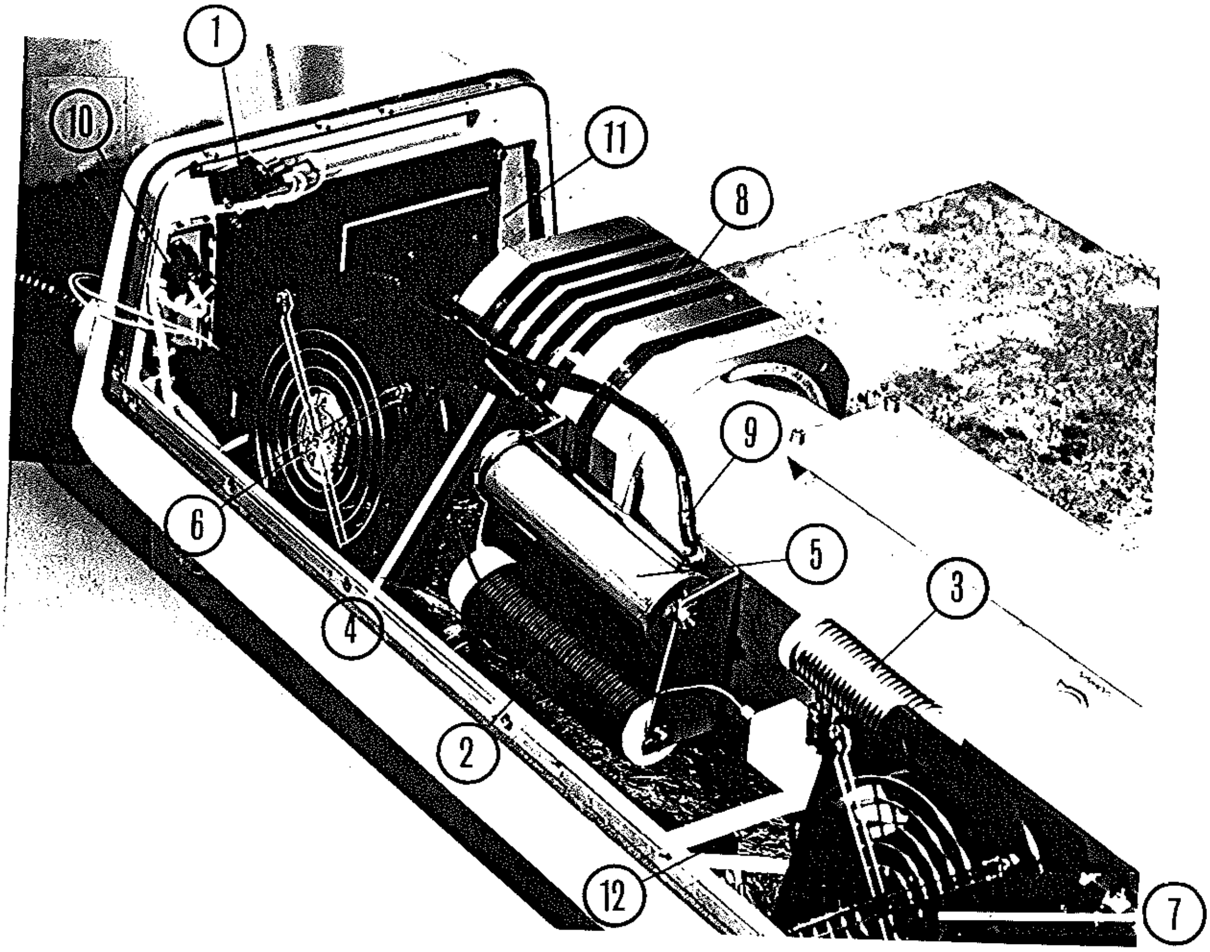

1. Resonant Charging Circuit
2. Thyratron tank
3. Thyratron Control Unit
4. Oil temperature switches
5. Smoothing capacitors
6. Smoothing inductors
7. TC 160
8. Thyristor unit
9. Dump switch
10. High voltage transformer
11. High voltage circuit breaker
12. High voltage rectifiers

Figure 9.3 HV side of PSU



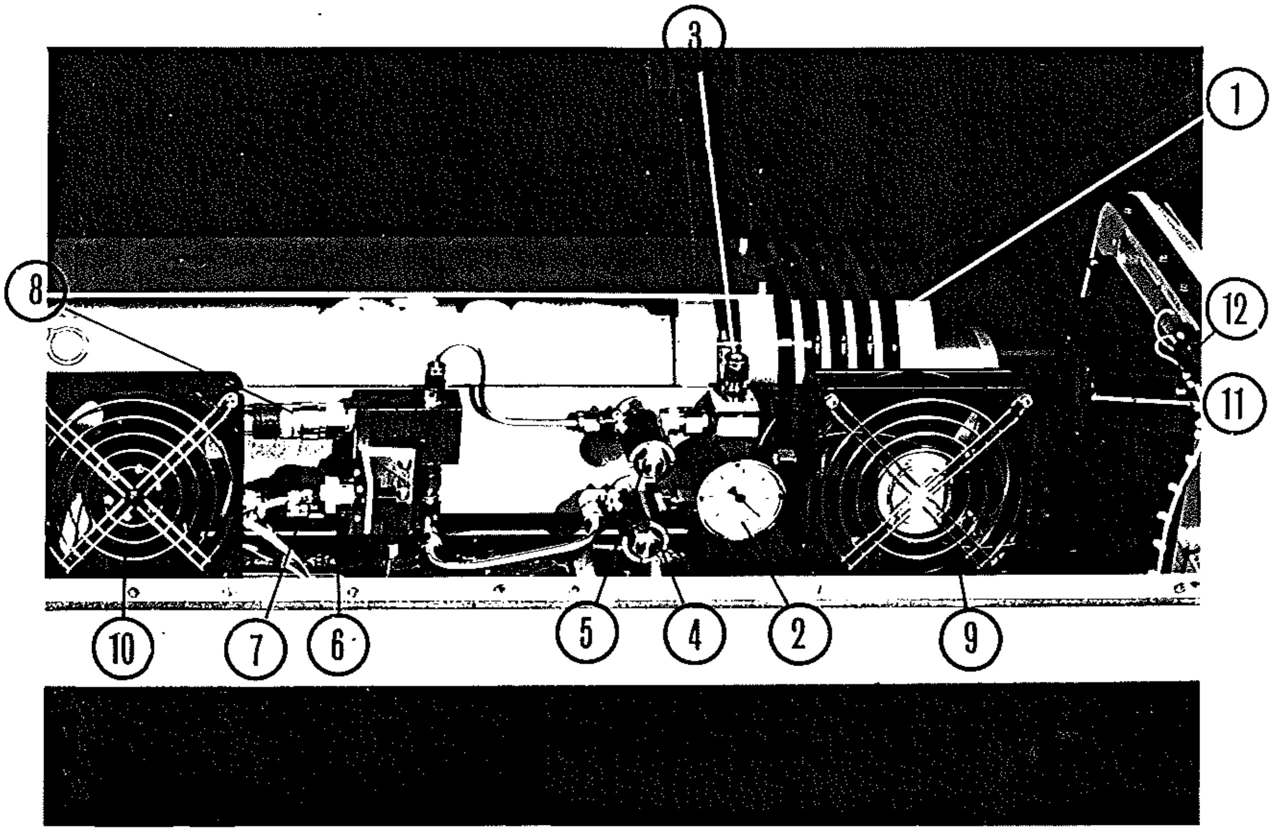

1. Gas manifold, valves, and switches
2. Power controller unit (with Condition Timer removed)
3. Vacuum pump
4. Motherboard and interlock override PCBs
5. Battery for fans
6. Power supply filter
7. Oil mist filter
8. PSU transformer for low voltage supply
9. CLP unit
10. Gas cylinder retaining brackets

Figure 9.4 Control circuits side of PSU



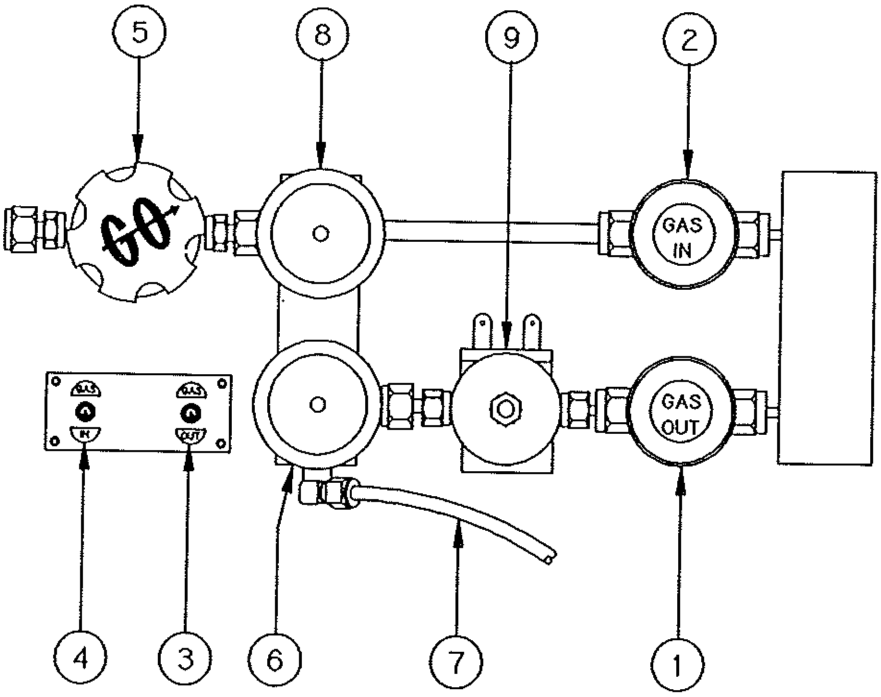

1. Laser head Interlock Microswitch
2. Pulsed Circuit Charging Inductor
3. Gas input restrictor
4. Pulsed HV connection
5. Peaking capacitor
6. 24V fan (draws air in)
7. 240V fan (draws air out)
8. HV end flange
9. Earth connect and return
10. HV on indicator
11. Rear mirror mount
12. Power in "Bulge-in" connector

Figure 9.6 Detail of HV end of laser



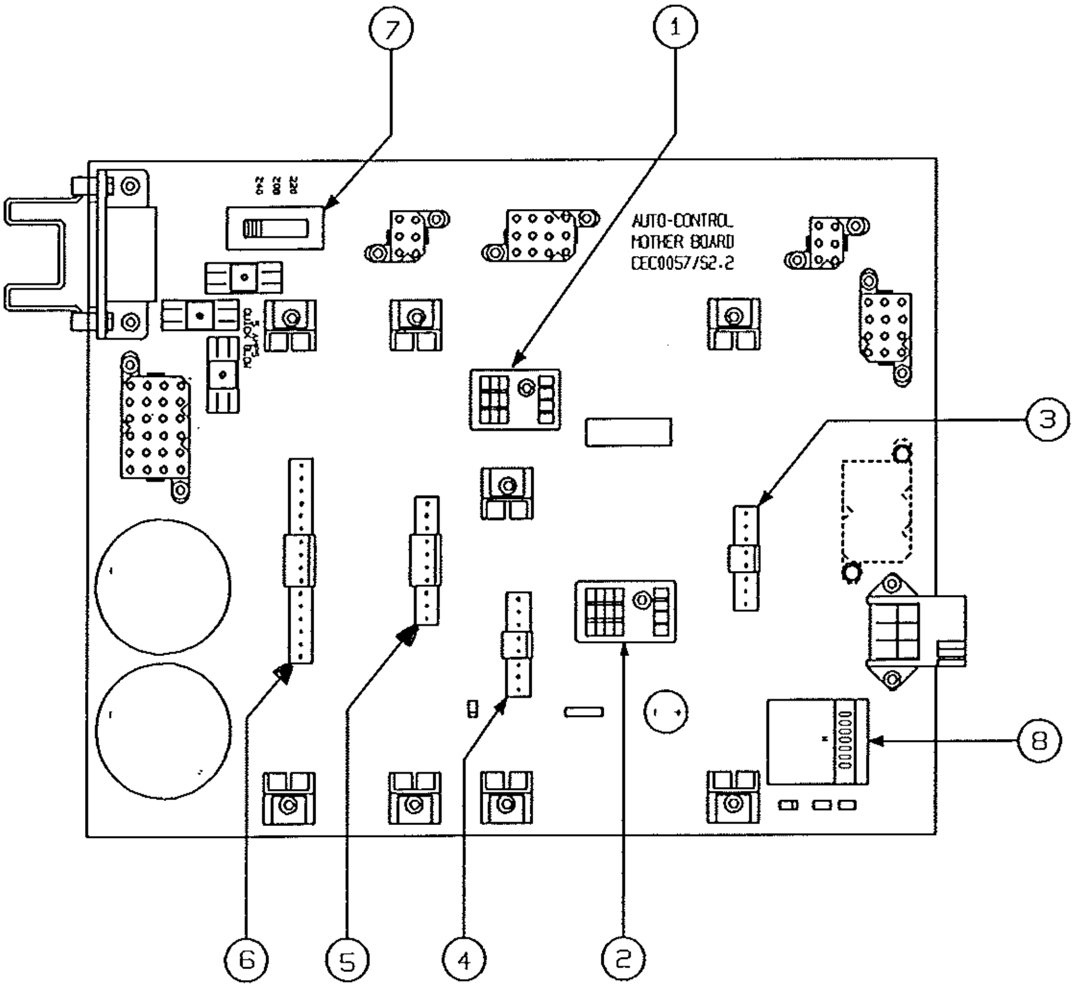

1. Earth end flange
2. Pressure gauge
3. Port for external gauge
4. Fast pump-out solenoid valve
5. Slow pump-out solenoid valve
6. Power connector for solenoid valves
7. Gas in line
8. Gas out line
9. 24V fan (draws air in)
10. 240V fan (draws air out)
11. Output coupler mount
12. Laser head interlock microswitch

Figure 9.5 Detail of earthed end of laser



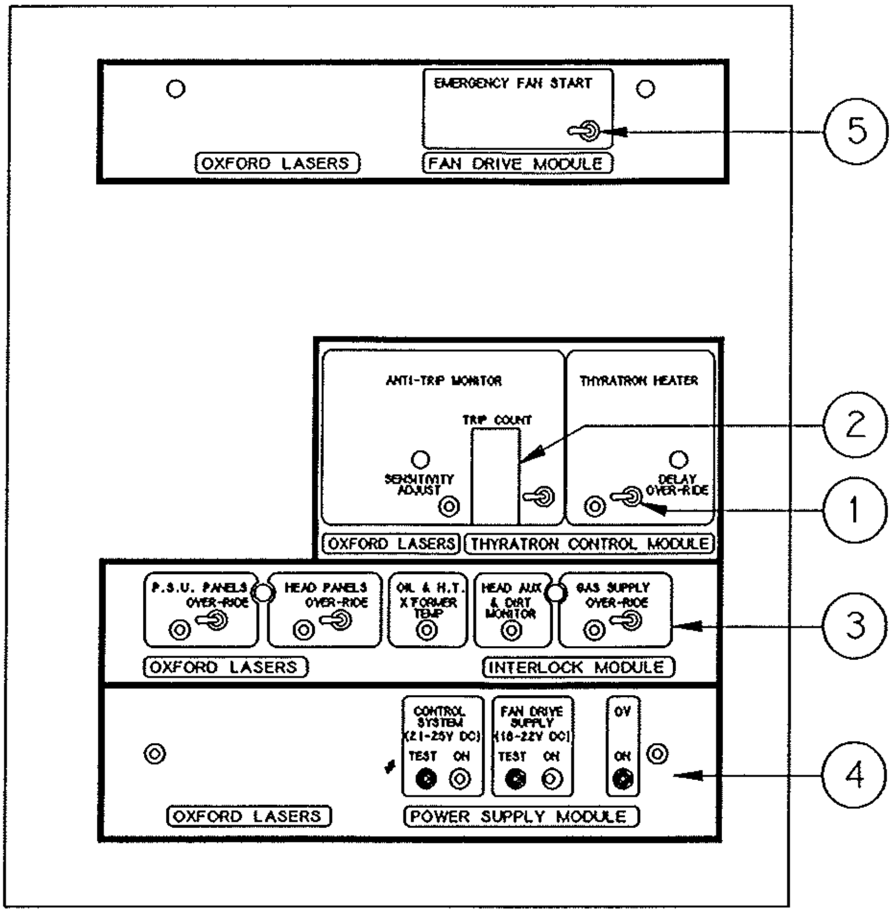

1. Manual gas out regulating and shut off valve
2. Manual gas in regulating and shut off valve
3. Gas out fast pump override switch
4. Gas in fast pump override switch
5. Pressure input regulator
6. Vacuum interlock switch
7. Vacuum pump line
8. Pressure interlock switch (gas supply)
9. Solenoid valve: 2-way vacuum pump air inlet

Figure 9.7 Detail of gas handling manifold on PSU



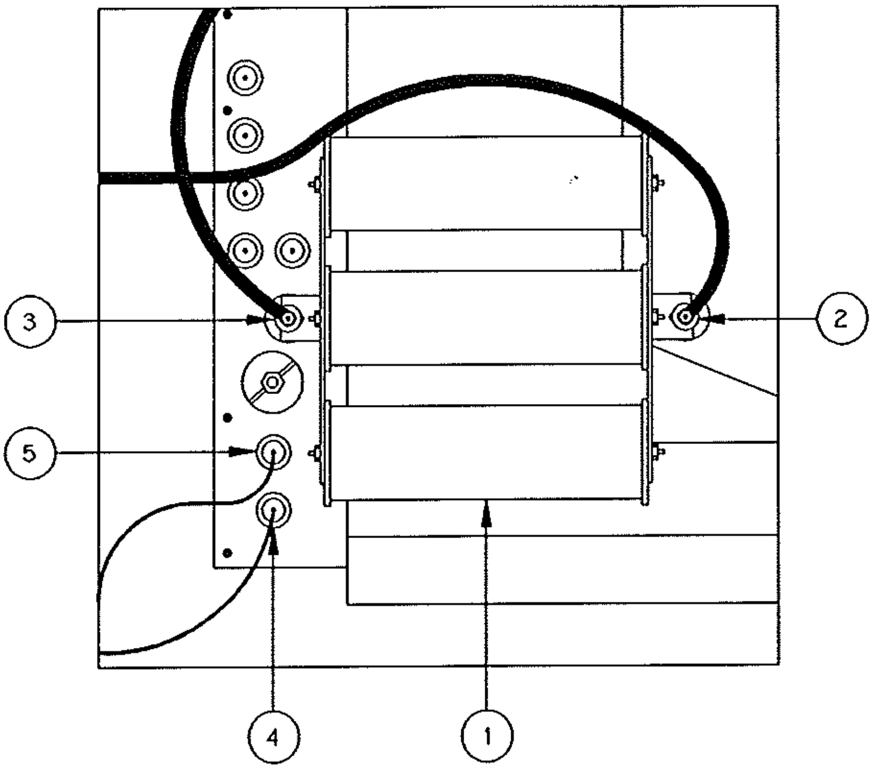

1. Connection for 5A Cradle Relay (8 pin)
2. " " 5A Cradle Relay (14 pin)
3. " " Fan drive module
4. " " Thyratron control module
5. " " Interlock module
6. " " Power supply module
7. Voltage select
8. HV on timer

Figure 9.8 Location of relays



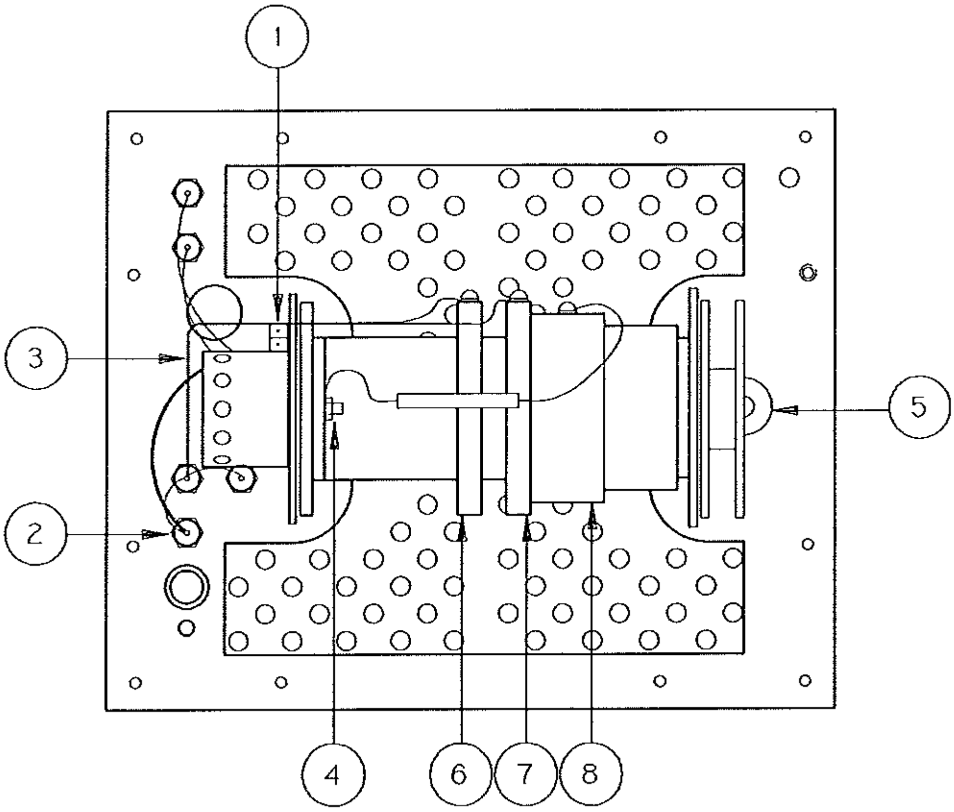

1. Thyratron delay override switch
2. Anti-Trip counter and reset
3. Interlock override module
4. Low voltage power supply module
5. Emergency fan override

Figure 9.9 Location of interlock override and reset switches



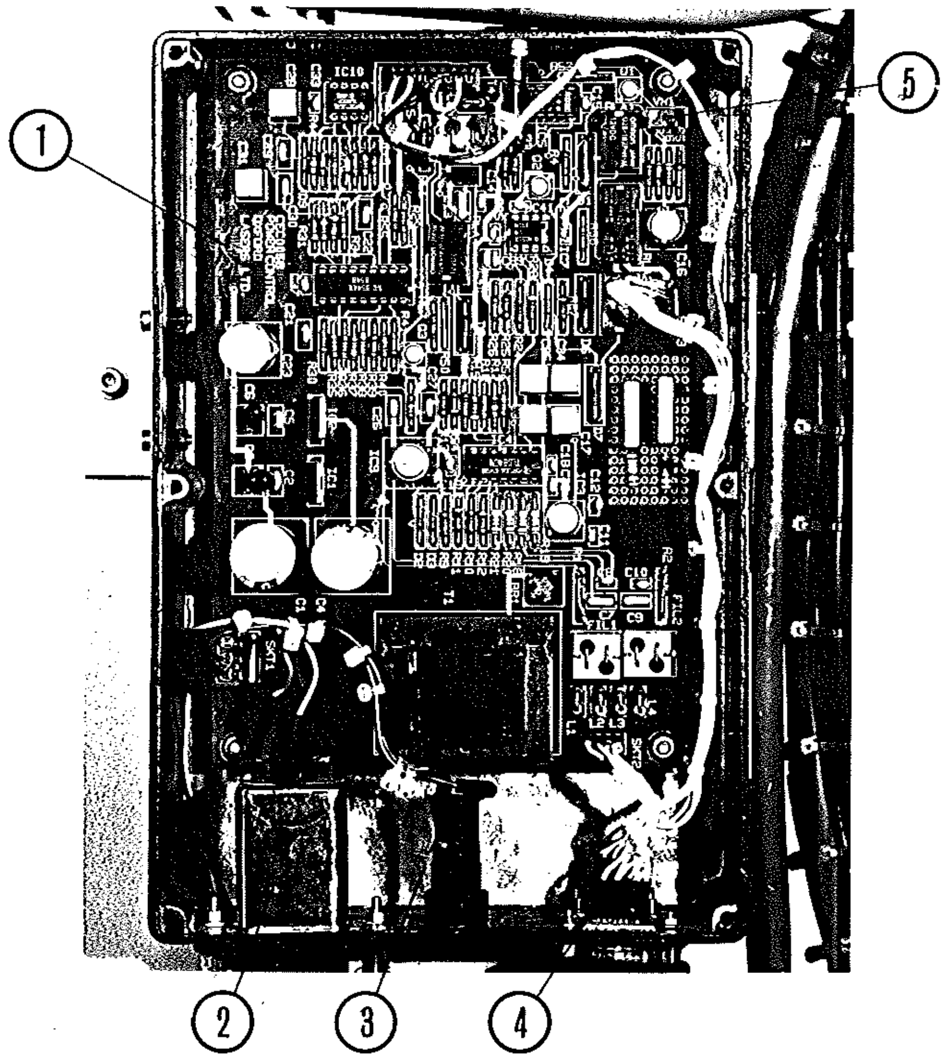

1. Capacitor Bank
2. DC input
3. Pulsed output (to anode of Thyratron)
4. Positive (+ve) trigger input
5. Negative (-ve) trigger input

Figure 9.10 Capacitor bank assembly



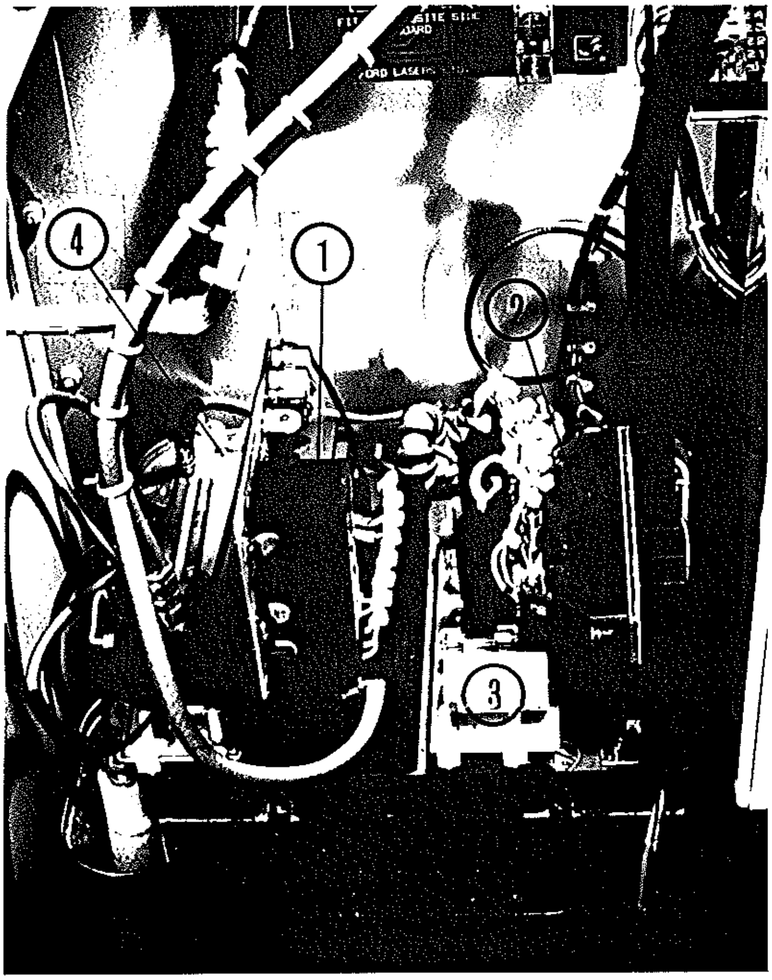

1. Negative and positive grid bias resistors
2. Connection point for Thyratron heater wires;
3. Thyratron heater wires
4. One of the Thyratron retaining screws
5. Heatsink and braid on the Thyratron anode.
6. Positive grid
7. Negative grid
8. Earth grid

Figure 9.11 Thyratron mounting plate before replacement in the thyratron tank



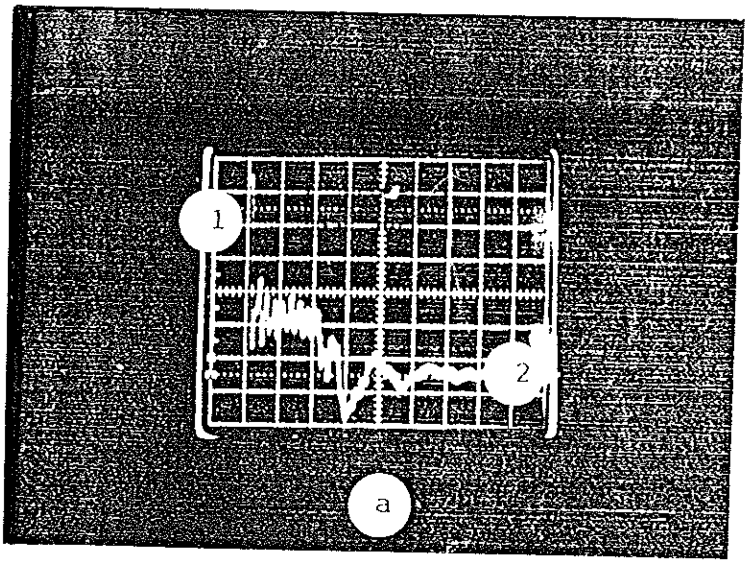

1. Power controller PCB
2. Filtered power input (240V)
3. Power supply input fuse
4. Signal input and output cables
5. Trimpot for laser power input control

Figure 9.12 Power controller unit



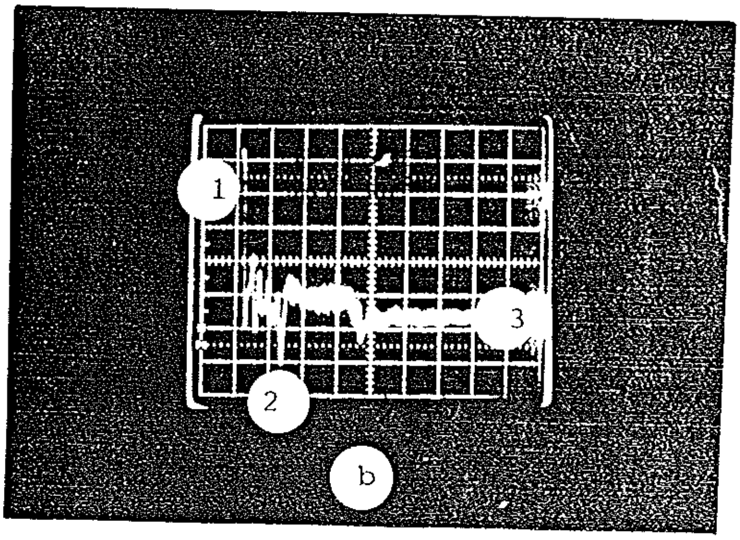

1. TC 160 Thyristor controller
2. Thyristor unit
3. Snubber PCB
4. High voltage sense PCB

Figure 9.13 HV sense and Thyristor unit




a) **Laser Clean**

1. Initial Breakdown; 2. Voltage Overswing




(b) **Laser Contaminated**

1. Initial Breakdown; 2. Dirt Spike; 3. Voltage Overswing.

Figure 9.14 Voltage waveforms on the thyratron anode